Momentum in dynamic contests∗
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ABSTRACT
We consider a two-player advertising race subject to momentum. Momentum is modeled as a complementarity between current and past campaign spending in a way that is reminiscent of models of addiction and habit formation: the more effective a player’s past spending has been, the more effective her future spending will be. For symmetric races in which the effectiveness of spending is of the Cobb-Douglas form, we derive analytic solutions for the equilibrium path. Our theory rationalizes alternative campaign strategies including aggressive openings and the development of a war chest for a final campaign assault.

1. Introduction
We examine the optimal sequencing of a scarce advertising budget in contests subject to momentum. Our premise is that the effectiveness of advertising improves with the receptiveness of the audience. For example, consumers pay more attention to products that interest them; and voters are more likely to be swayed by the arguments of candidates they prefer. In the presence of such momentum, should combatants commence early and devote substantial resources to kickstart the advertising campaign, or would they be better served by saving resources for a vigorous assault at the end of the campaign?

For clarity, we maintain a running example of a political contest throughout the paper, although one should keep in mind that our approach lends itself to other applications. Related tradeoffs arise in the marketing of competing products, such as the looming opening of two rival game consoles or the release of two potential blockbuster movies in peak season. Sporting contests also give rise to similar considerations: decay, diminishing returns, and momentum. Decay and diminishing returns are common features in advertising settings, each candidate decides how to sequence a limited campaign budget over time in order to maximise her electoral chances. The shape of the dynamic spending profile is influenced by three principal considerations: decay, diminishing returns, and momentum. Decay reflects the increased electoral salience of campaign events that occur closer to election day. Recent campaign events are likely to be fresh in the minds of voters on polling day, encouraging combatants to nurture a war chest for a final campaign push. The presence of diminishing returns restricts the capacity of the electorate to receive and absorb messages, placing a limitation on the effectiveness of intense campaigning. Careful, targeted campaigning may be able to reach the most receptive and available of voters at minimal cost. However, even saturation coverage may not be able to influence or even attract the attention of some voters. This provides an incentive to smooth campaign spending over time.

Decay and diminishing returns are common features in advertising models, while momentum is a novel inclusion. To illustrate the role of momentum, consider a race between two politicians running for the same office. Suppose that one of them has succeeded in getting ahead

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1 As Denter and Sisak (2015) note, more than USD 2 billion was spent on the 2012 United States Presidential Campaign.
2 The correspondence between advertising and campaigning is not a novel insight. See, for example, Snyder (1989).

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in the polls, thus having gained momentum over her opponent. Then, one might expect that it will be easier, loosely speaking, for the political leading the polls to maintain her lead and, perhaps, reinforce it. For example, if from this point onwards until election time both politicians match each other’s campaign efforts, we might expect the leading politician to not only maintain her lead to the end, but strengthen it even further. In our model, momentum operates by increasing the effectiveness of campaigning for popular candidates. This provides a payoff to an aggressive early campaign strategy.3

Momentum effects may arise due to different underlying forces and our formulation does not take a position on the precise source. In a political campaign, momentum may arise due to the electorate’s imperfect memory. More specifically, Mullainathan (2002) points to a large body of psychological research suggesting that memory operates on the principles of cue-dependence and rehearsal. According to cue-dependence, events tend to trigger memories of similar past events. As these past events are triggered, they get rehearsed and thus their memories are strengthened. In turn, this makes it even more likely that they will be further rehearsed by similar events that may follow in the future. One can thus interpret a lead by one politician in the polls as that politician having created a superior stock of good memories in the electorate’s mind, relative to her opponent. As a result, due to the principles of cue-dependence and rehearsal, her future advertising spending will be, all else equal, more successful than her opponent’s, as it will be rehearsing a superior stock of existing memories; i.e. the leading politician has gained momentum.

Alternative forces may also give rise to momentum. For instance, in the context of our console example, momentum may arise if consumer interest is piqued by prior advertising, encouraging consumers to pay more attention to subsequent advertising. Network effects could also play a role. Consumers may pay more attention to a console that is showing early signs of popularity. In a political contest, a voter who forms a favorable impression of a candidate is more likely to engage in increasing the effectiveness of his advertising. As a result, due to the principles of cue-dependence and rehearsal, his future advertising spending will be, all else equal, more successful than his opponent’s, as it will be rehearsing a superior stock of existing memories; i.e. the leading politician has gained momentum.

5 The starting point of our theory is that campaign spending is effective in the context of political campaigns, this position is not without controversy (see, for example, Holbrook (1996), Shaw (1999), and Jacobsen (2015) for a discussion).4 Erikson and Palfrey (2000)

argue that the inherent difficulty of empirically inferring the causal relationship between campaign spending and outcomes may be to blame: if campaign success itself influences campaign spending, it is challenging to isolate the effectiveness of campaign spending. Our model provides an illustration. Despite our presumption of effective campaigning, equilibrium behaviour may not induce a correlation between campaign intensity and campaign outcomes.

1.1. The set up and main results

To set the stage, consider a single politician with a fixed advertising budget. Following Nerlove and Arrow (1962), we allow advertising to generate a stock of goodwill, which decays at a fixed rate, δ. Our politician wishes to maximise her stock of goodwill at a critical time, T (e.g. at election time). The marginal effect of her advertising spending in each period depends on her existing stock of goodwill. That is, it is possible for her to create momentum during the campaign. How should she then sequence her scarce advertising budget to maximise her stock of goodwill at election time?

We show that this problem is isomorphic to a standard intertemporal utility maximization model with addiction or habit formation and there is nothing here we claim to be novel. We thus view the single-agent problem as a stepping stone towards the two-agent game. As we will see, it also provides a useful benchmark. We show that under a payoff function of the Cobb-Douglas form (with the two arguments being the advertising flow and the existing stock of goodwill), the politician’s optimal strategy is to advertise at a (weakly) increasing exponential rate as in the model with no momentum, with this rate being (weakly) decreasing in the parameter that measures the magnitude of the momentum effect. In other words, relative to the model with no momentum effects, the optimal path has the same qualitative features, but is flatter. With an increasing path of spending, a flatter path is equivalent to a more aggressive initial campaign: the politician strives to build early on a healthy stock of goodwill that will enhance the impact of future campaigning.

We then analyze a differential game between two such politicians. Each politician now nurtures a separate stock of goodwill. Not only must each politician consider the effect of her stock of goodwill on her own advertising effectiveness, but she should also contemplate the impact her advertising has on her rival’s spending pattern and stock of goodwill, as well as the manner in which this feeds back into her own stock of goodwill.

We assume that each politician’s objective is to maximize the lead over her opponent at election time. An alternative formulation that might be of some interest is a binary objective function. This would be the case if the politician simply wanted to win the election by being ahead on election day. We think our formulation is of interest for at least two reasons (but see Snyder (1989) for an example where these goals can lead to different outcomes). First, our politician will care, at least to some extent, about the margin of her victory as this will influence her mandate for action (and potentially stoke her ego). Indeed, in proportional representation settings, the margin of victory has obvious importance. Second, even if our politician is primarily concerned about winning per se, in a stochastic setting she will be more secure in her likelihood of winning the greater her expected margin over her opponent. Similar considerations apply in marketing and sporting settings.

(footnote continued)

contrast, Box-Steffensmeier et al. (2009) emphasise the importance of careful account of the co-dependence of principal actors in a campaign including political candidates, the media, and voters. While we do not explicitly model these relationships, our model assumes a feedback relationship between campaign spending and voter support.

5 The “weakly” qualifier is needed because the optimal strategy is to advertise at a constant rate, regardless of the magnitude of the momentum effect, if and only if the stock of goodwill does not decay (i.e. δ = 0).
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